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C1D
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F42B C06B

(54) **Cartridging of explosives**

(57) A non-cap sensitive water-in-oil emulsion explosive base is injected successively into shells through a nozzle into which a chemical gassing solution is simultaneously fed at 26. The gassing solution is mixed with the base in the nozzle by a static mixer 20 so that the mixture issuing from the nozzle into the shell is a cap-sensitive water-in-oil emulsion explosive. Advantageously the gassing solution is supplied from a pressurisable vessel which may be pressurised intermittently to inject solution into the nozzle in synchronization with the injection of predetermined quantities of emulsion base through the nozzle by means of a positive displacement reciprocating closing pump.

The invention effects accurate gassing of explosive emulsion immediately prior to filling the shells so that the amount of sensitised explosive within the apparatus is kept to a minimum.

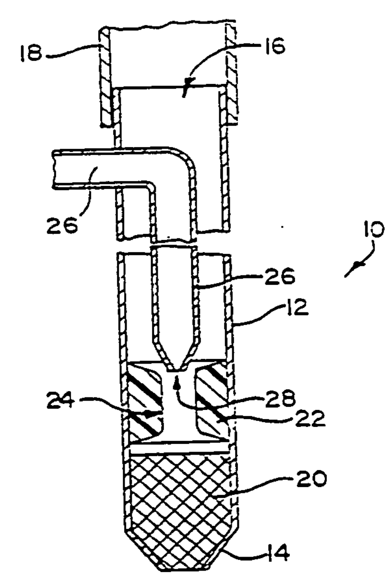

FIG 1

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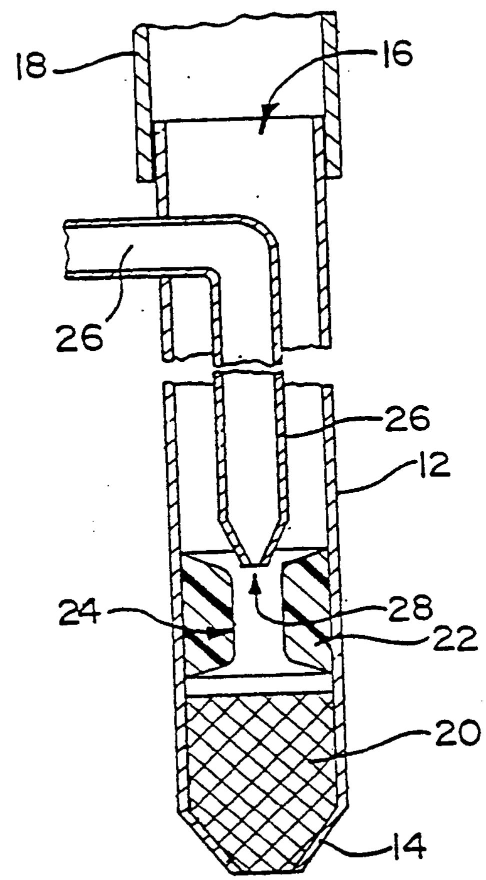
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FIG 1

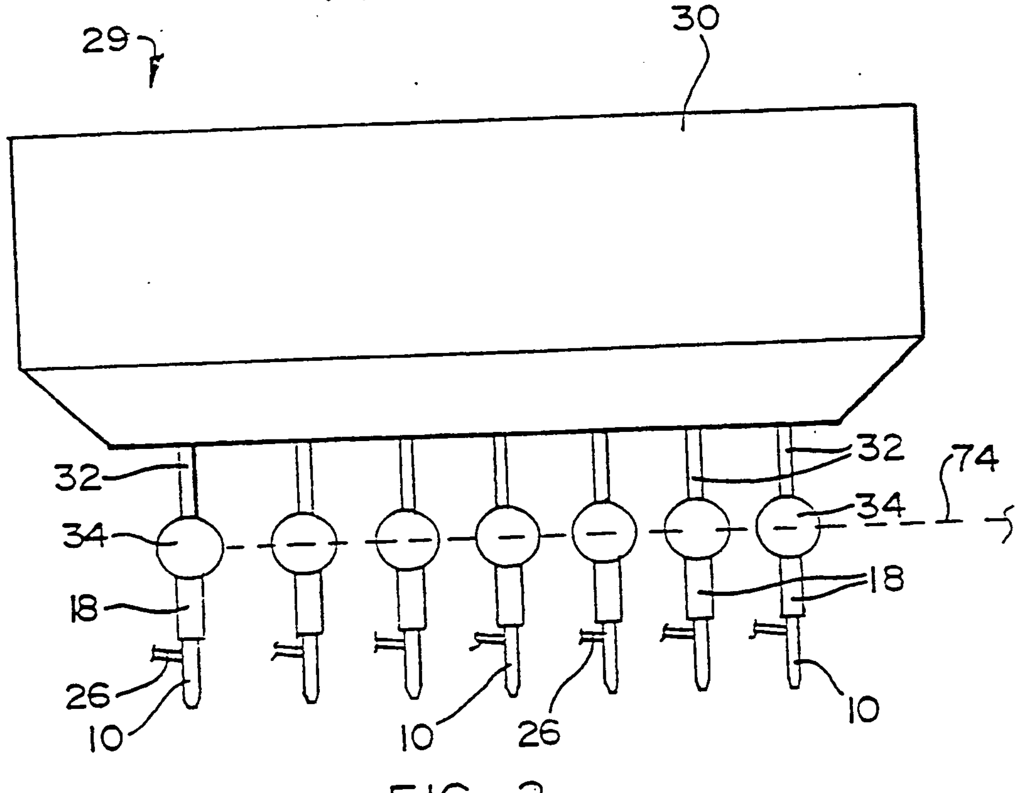
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FIG 2

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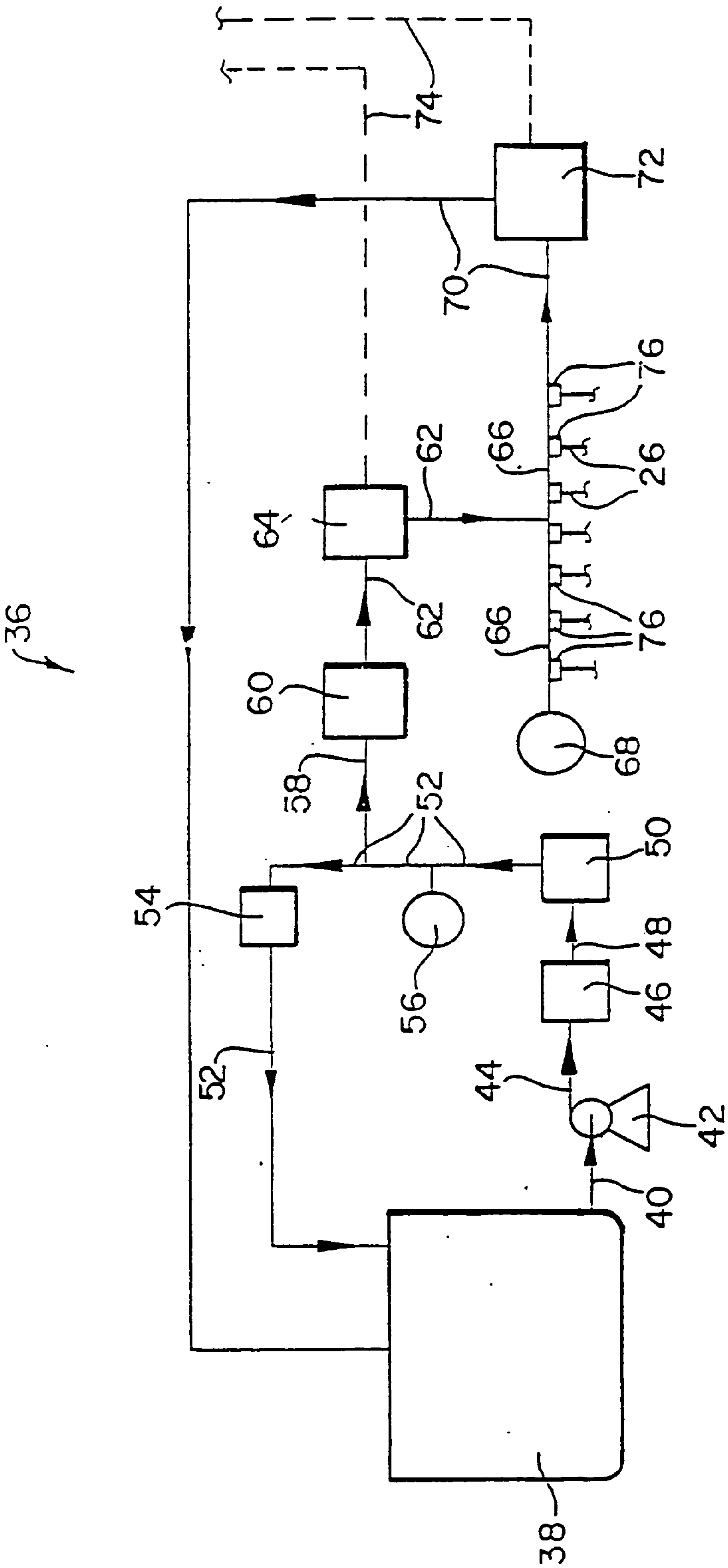

FIG 3

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CARTRIDGING OF EXPLOSIVES

THIS INVENTION relates to the cartridging of explosives. More particularly it relates to a method of cartridging a cap-sensitive water-in-oil emulsion explosive; to a cartridge filler nozzle for loading a cap-sensitive water-in-oil emulsion explosive into cartridge shells, and to a cartridging apparatus for this purpose.

According to the invention, in the cartridging of a cap-sensitive water-in-oil emulsion explosive by injecting it from a bulk supply in succession into a plurality of cartridge shells by means of a cartridge filler nozzle, there is provided a method which comprises injecting a non-cap-sensitive water-in-oil emulsion explosive base through at least one nozzle successively into the shells and, while the base is being injected through each nozzle to each shell, feeding a chemical gassing solution into the explosive base in the nozzle and mixing the gassing solution with the base in the nozzle so that a mixture issues from the nozzle into the shell, to provide a cap-sensitive water-in-oil emulsion explosive in the shell.

Typically a plurality of such nozzles will form part of a cartridging apparatus which comprises an emulsion hopper containing the emulsion, each nozzle being connected to the hopper by a positive displacement dosing pump, each stroke of each pump delivering a predetermined quantity of emulsion through the associated nozzle into a shell to load the shell with emulsion, after which the loaded cartridge is removed and replaced by the succeeding shell to be loaded by the next stroke of the pump.

Each nozzle may be fed with a chemical gassing solution from a supply thereof in a pressurisable vessel, each nozzle being individually

connected to said supply by a solution delivery tube, the tube having an outlet in the associated nozzle, the method comprising pressurising the vessel intermittently and injection through each nozzle being effected in synchronization with the pressurisation so that the vessel is pressurised when base is being injected through the nozzle into the shell, and is unpressurised when base is not being injected through the nozzle.

There may be a plurality of nozzles, connected respectively to a common bulk supply in the form of a hopper containing explosive base by a plurality of positive displacement reciprocating dosing pumps each having a working stroke and a return stroke, each working stroke of each pump injecting a predetermined full load of base through its associated nozzle to load the shell, and the loaded shell being removed and replaced by a succeeding shell for loading by the next stroke of the pump. The pumps may be operatively synchronized so that their pumping strokes occur simultaneously, the delivery tubes being connected to a common supply of gassing solution.

The vessel may be in the form of a pressurisable manifold, the manifold having an inlet provided with a shut-off valve and an outlet provided with a shut-off valve, the shut-off valves being solenoid-controlled and operatively synchronized with the dosing pumps so that the inlet valve opens and the outlet valve closes at the start of each working stroke of the pumps, and so that the inlet valve closes and the outlet valve opens at the end of each said working stroke, the manifold having its inlet connected to a high pressure part of a flow circuit and its outlet connected to a low pressure part of the circuit, and the method including circulating gassing solution under pressure around the circuit.

As each pump pumps emulsion through the associated nozzle, gassing solution is accordingly fed into the nozzle via the associated delivery tube, and when each pump stops pumping, pressure in the delivery tube is relieved, interrupting flow of gassing solution into the nozzle.

Each nozzle may be provided with a flow restriction through which base injected through the nozzle passes at a higher speed and at a lower

pressure than elsewhere in the nozzle, the method including feeding the chemical gassing solution into the nozzle at or adjacent the restriction in a zone of relatively high speed and low pressure. Mixing the base and gassing solution in the nozzle may be effected by passing them together through a mixing device, such as an orifice plate or static mixer, mounted in the nozzle downstream of the positions where base and gassing solution are fed into the nozzle.

Further according to the invention there is provided a cartridge filler nozzle for loading a cap-sensitive water-in-oil emulsion explosive into cartridge shells, the nozzle having a base inlet for non-cap-sensitive emulsion base, an outlet, a gassing solution inlet at a position between the base inlet and the outlet, and a mixing device in the nozzle downstream of the inlets and upstream of the outlet, the mixing device being arranged so that liquids fed simultaneously into the inlets are passed through the mixing device to be mixed together before they issue from the outlet.

The mixing device may be in the form of an orifice plate or a static mixer, the nozzle having a flow restriction, such as a venturi, in its interior between the base inlet and the outlet and upstream of the mixing device, and the gassing solution inlet entering the nozzle at a position in or closely spaced upstream of the flow restriction. Thus, the mixing device may be located at, or upstream and as close as practicable adjacent the outlet of the nozzle; and the gassing solution inlet may feed into the nozzle at or upstream adjacent a mouth of a venturi.

In a particular embodiment, the nozzle may be of circular cross-section, the flow restriction being centrally located in the nozzle and arranged so that liquid flow through the restriction is axially along the nozzle, the gassing solution inlet to the nozzle being provided by the outlet of a gassing solution delivery tube fast with the nozzle and projecting into the interior of the nozzle, the delivery tube, in the vicinity of its outlet, extending concentrically in the nozzle in a direction away from the flow restriction and towards the base inlet of the nozzle, and the outlet of the tube being directed into the flow restriction.

The invention extends further to a cartridging apparatus for loading water-in-oil emulsion explosive into cartridge shells, the apparatus including an emulsion base hopper and at least one positive displacement reciprocating dosing pump having an inlet connected to the hopper and an outlet connected to the emulsion base inlet of a nozzle as described above.

The apparatus may include a plurality of said nozzles, each individually connected to an associated said pump, the pumps each being connected to a single said hopper and being operatively connected to drive means, the drive means being arranged to drive the pumps synchronously, so that they undergo working strokes simultaneously.

The apparatus will naturally have the usual cartridge handling means for aligning shells to be filled with the nozzles, and for removing and closing filled cartridges.

The gassing solution inlets of the nozzles may be connected to a common supply vessel, said vessel being in the form of a manifold having an inlet connected to a high pressure part of a circuit for circulating gassing solution under pressure, and an outlet connected to a low pressure part of said circuit, the inlet and outlet of the manifold each being provided with a shut-off valve and the shut-off valves being operatively synchronized with the dosing pumps so that the valve of the manifold inlet opens, and the valve of the manifold outlet closes, at the start of each pump working stroke, and so that the valve of the manifold inlet closes, and the valve of the manifold outlet opens, at the end of said working stroke.

The invention will now be described, by way of example, with reference to the accompanying schematic drawings, in which:-

Figure 1 shows a diagrammatic sectional side elevation of the downstream portion of a nozzle according to the invention;

Figure 2 shows a diagrammatic side elevation of part of a cartridging apparatus according to the invention; and

Figure 3 shows a flow diagram of part of a cartridging installation according to the invention.

In Figure 1 of the drawings, reference numeral 10 generally designates a cartridge filler nozzle according to the invention. The nozzle has a

tubular body 12 provided with a tapered outlet 14, and an inlet 16 shown connected to a supply pipe 18. A static mixer 20 is shown located in the body 12 adjacent the outlet 14, and an insert 22 providing a venturi-type constriction 24 in the nozzle, is located in the body 12, immediately upstream of the mixer 20. A gassing solution delivery tube 26 protrudes into the body 12 upstream of the insert 22 and has an outlet orifice 28 directed into the upstream or inlet end of the constriction 24.

Turning to Figure 2, part of a cartridging apparatus according to the invention is designated 29 and comprises an emulsion hopper shown at 30, provided with a plurality of outlet pipes 32, each leading to a positive displacement dosing pump 34. Each pump 34 feeds into a supply pipe 18 (see Figure 1) which in turn leads to a nozzle 10.

Turning to Figure 3, part of the flow diagram of an installation according to the invention is designated 36. The installation comprises a gassing solution holding tank 38 having an outlet flow line 40 leading to a delivery pump 42. The pump 42 in turn has an outlet flow line 44 leading to an ASTM 40-mesh (ie about 0,4 mm mesh size) filter 46. A flow line 48 extends from filter 46 to a flow meter/indicator 50, and flow line 52 extends from the meter 50 back into the tank 38. A pressure control valve 54 is provided in flow line 52, and, connected to line 52 between meter 50 and valve 54, there is a pressure gauge 56 for measuring pressure in flow line 52.

A flow line 58 branches off flow line 52 between the gauge 56 and valve 54 and leads to a 40 micron mesh size filter 60. From the filter 60 a flow line 62, provided with a solenoid-operated shut-off valve 64, leads to a manifold 66. Manifold 66 is connected to a pressure gauge 68 and feeds via a plurality of orifices 76 into a plurality of delivery tubes 26 having outlet orifices 28 (see Figures 1 and 2). A return flow line 70, provided with solenoid-operated shut-off valve 72, leads from the manifold 66 back into the tank 38.

Pumps 34 (Figure 2) and valves 64, 72 (Figure 3) are operatively synchronized by suitable electrical circuitry, indicated by dotted lines 74 in Figures 2 and 3.

In use a batch of sodium nitrite gassing solution is mixed and charged into tank 38,and a batch of water-in-oil non-cap-sensitive emulsion is formulated and charged into hopper 30. Pump 42 is then used to circulate solution from tank 38 around the circuit constituted by flow lines 40, 44, 48 and 52, back into tank 38. Valve 54 is used to set the pressure in flow lines 52 and 58 to a desired value as indicated by gauge 56, and indicator 50 indicates that flow is taking place.

The apparatus 29 of Figure 2 is operated in the usual way, to bring a succession of cartridge shells into register with the nozzles 10, followed by filling of the shells via said nozzles 10 by means of the pumps 34, after which the shells are closed and removed eg to cooling (not shown).

It is a feature of the invention that the pumps 34, which are typically piston and cylinder-type positive displacement dosing pumps, work in synchronization, so that they all undergo a working stroke simultaneously and a return stroke simultaneously. Via the circuitry 74, the pumps 34 are in turn synchronized with valves 64 and 72 (Figure 3), so that valve 64 is opened and valve 72 is closed for the whole of each working stroke of the pumps 34, and valve 64 is closed and valve 72 opened at all other times, eg during return strokes of the pump 34, or when they are inoperative.

Accordingly, during each working stroke of the pumps 34, emulsion is delivered via pipes 32 and pipes 18 to the nozzles 10, and via said nozzles into cartridge shells being filled. As flow of emulsion takes place through each nozzle 10, its associated delivery tube 26 (which is connected to the manifold 66) feeds gassing solution into the nozzle 10. The manifold 66 acts as a source of solution under pressure, as the valve 72 is closed, the valve 64 is open and the manifold 66 is thus pressurised to the pressure in lines 52 and 58 by pump 42 pumping against a back pressure caused by the valve 54, which throttles flow through flow line 52. Feed of gassing solution into the nozzle 10 controlled by the orifice 76 (Figure 3) is promoted by the venturi 24 which causes a zone of reduced pressure in the nozzle 10 adjacent the orifice 28 (Figure 1) of the tube 26, tending to draw gassing solution by suction into the nozzle 10. The gassing solution entering the nozzle

10 and the emulsion passing through said nozzle are thoroughly and homogeneously mixed in the mixer 20, immediately before the mixture issued into the shell being filled.

Pressure in the manifold 66 is automatically relieved between working strokes of the pumps 34, by opening of the valve 72 and closing of the valve 64. This, coupled with the fact that there is no flow of emulsion through the nozzles 10 between working strokes, causes gassing solution to stop flowing into the nozzles 10 between working strokes. The pump 42 can however continue to operate continuously, pumping via flow line 52 back into tank 38.

It is a further feature of the invention that accurate and simultaneous dosing of gassing solution into a plurality of nozzles can take place, followed by automatic mixing with emulsion prior to filing of shells. The exact proportion of gassing solution mixed with emulsion will depend on the geometry and construction of the nozzles 10, the dimensions of the orifices 76 and 28, temperatures of constituents, pressure in the manifold 66, operation rate of the pumps 34, etc. However, for identical pump/nozzle assemblies 34/10, connected to the same hopper 30 and manifold 66, accurate and identical dosing of solution into emulsion and mixing therewith should automatically take place in each nozzle 10. For a fixed construction, this dosing can be varied within limits by altering the pressure in the manifold 66 by changing the pressure in line 52 by means of valve 54.

It is a further particular feature of the invention that the amount of emulsion in the apparatus and installation in contact with gassing solution, other than that actually charged into the cartridges, is kept to a minimum, existing only in the venturi 24 and static mixers 20 of the nozzles 10. Indeed, an intimate mixture of gassing solution and emulsion only exists in the static mixer, and this is only sensitized when flow has ceased for a sufficient time for bubbles to form in emulsion in said mixers. Accordingly, if any stoppage takes place, there are no substantial quantities of sensitized emulsion present at all, and sensitized emulsion in the mixers 20 is arguably safer than that actually in the cartridges, bearing in mind the small diameters present in the passages of the mixers 20.

A chemically gassed water-in-oil emulsion explosive suitable for cartridging according to the method of the invention has the following emulsion base composition (excluding water):

CONSTITUENT	PARTS BY MASS
Ammonium Nitrate	70
Sodium Nitrate	10,07
Thiourea	0,1
Mineral Oil	0,99
Sorbitan Monooleate	1,39
Paraffin Wax	2,02
Microcrystalline Wax	2,02

This emulsion base is fed via nozzles 10 from hopper 30 into the cartridges, and tank 38 is charged with an aqueous sodium nitrite gassing solution comprising 1 part by mass of $NaNO_2$ for every 18 parts by mass water. The pressure in the manifold 66 is set so that during each working stroke gassing solution is mixed with base emulsion to give a composition as tabulated above which contains, in addition, 0,09 parts by mass $NaNO_2$ and a total of 12.12 parts by mass water, a small proportion of this water entering with the gassing solution and the remainder, ie 10.32 parts by mass, being present in the base emulsion.

The product is a sensitized emulsion explosive having a density of 1,10 g/mℓ which is sensitive to detonation by means of a 5D detonator containing 0,176 g of pentaerythritol tetranitrate in diameters of 25 and 32 mm, to give a velocity of detonation of 2,5 - 3,5 km/sec.

With regard to the above it should be noted that for the paraffin wax, Aristo wax available from Industrial Raw Materials (Proprietary) Limited can be used; and for the microcrystalline wax, BE SQUARE Amber 175 available from Industrial Raw Materials (Proprietary) Limited and made by Bareco Inc, USA can be used. A typical mineral oil is P95 oil available from BP South Africa (Proprietary) Limited, and a suitable sorbitan monooleate is Crill 4 available from Croda Chemicals South Africa (Proprietary) Limited.

After cartridging the nitrite ions of the sodium nitrite react with the thiourea and the ammonium ions of the ammonium nitrate to produce nitrogen gas and water, and the cartridges should be cooled as soon as possible by circulating chilled fluid thereover (eg water if the shells are plastics material and air if they are paper), preferably so that the fuel solidifies in less than about 5 minutes to entrap the nitrogen in place, in the form of suitably sized bubbles homogeneously distributed in the explosive.

In tests conducted by the Applicant, a water-in-oil emulsion explosive base was tested of the following composition by way of non-limiting illustrative example:

CONSTITUTENT	PARTS BY MASS
Ammonium Nitrate (88% by mass solution in water)	76,76
Sodium Nitrate	12,52
Water	0,22
Thiourea	0,05
P95 Oil	0,79
Crill 4	1,17
Paraffin Wax	2,13
Microcrystalline Wax	1,15
Atomized Aluminium	3,50.

The base was mixed in the nozzles with 0,09 parts by mass of sodium nitrite dissolved in 1,62 parts by mass of water. The paraffin wax was Nippon 150/15, available from Industrial Raw Materials (Proprietary) Limited; the microcrystalline wax was INDRAMIC 7080 WBW, available from Industrial Raw Materials (Proprietary) Limited; and the aluminium wax SUPRAMEX 2022, available from Hulett Aluminium Limited. Cartridging took place with the base at a temperature of 92°C, and the discontinuous phase had a crystallizing temperature or fudge point of 78°C.

The cartridges were found to fire with a velocity of detonation of 2,8 - 3,5 km/sec; and for minimum initiation a detonator of from No.2D - No.4D was required (the former containing 0,022 g of pentaerythritol tetranitrate and the latter containing 0,090 g thereof). Bubble energies were found to be in the vicinity of 2,0 MJ/kg.

A hundred cases of cartridges with this emulsion cartridged in accordance with the method were subjected to trials underground in gold mines. Satisfactory advances and fragmentations were obtained.

CLAIMS

1. In the cartridging of a cap-sensitive water-in-oil emulsion explosive by injecting it from a bulk supply in succession into a plurality of cartridge shells by means of a cartridge filler nozzle, a method which comprises injecting a non-cap-sensitive water-in-oil emulsion explosive base through at least one nozzle successively into the shells and, while the base is being injected through each nozzle to each shell, feeding a chemical gassing solution into the explosive base in the nozzle and mixing the gassing solution with the base in the nozzle so that a mixture issues from the nozzle into the shell, to provide a cap-sensitive water-in-oil emulsion explosive in the shell.

2. A method as claimed in Claim 1, in which each nozzle is fed with a chemical gassing solution from a supply thereof in a pressurisable vessel, each nozzle being individually connected to said supply by a solution delivery tube, the tube having an outlet in the associated nozzle, the method comprising pressurising the vessel intermittently and injection through each nozzle being effected in synchronization with the pressurisation so that the vessel is pressurised when base is being injected through the nozzle into the shell, and is unpressurised when base is not being injected through the nozzle.

3. A method as claimed in Claim 2, in which there are a plurality of nozzles, connected respectively to a common bulk supply in the form of a hopper containing explosive base by a plurality of positive displacement reciprocating dosing pumps each having a working stroke and a return stroke, each working stroke of each pump injecting a predetermined full load of base through its associated nozzle to load the shell, and the loaded shell being removed and replaced by a succeeding shell for loading by the next stroke of the pump.

4. A method as claimed in Claim 3, in which the pumps are operatively synchronized so that their pumping strokes occur simultaneously, the delivery tubes being connected to a common supply of gassing solution.

5. A method as claimed in Claim 4, in which the vessel is in the form of a pressurisable manifold, the manifold having an inlet provided with a shut-off valve and an outlet provided with a shut-off valve, the shut-off valves being solenoid-controlled and operatively synchronized with the dosing pumps so that the inlet valve opens and the outlet valve closes at the start of each working stroke of the pumps, and so that the inlet valve closes and the outlet valve opens at the end of each said working stroke, the manifold having its inlet connected to a high pressure part of a flow circuit and its outlet connected to a low pressure part of the circuit, and the method including circulating gassing solution under pressure around the circuit.

6. A method as claimed in any one of the preceding claims, in which each nozzle is provided with a flow restriction through which base injected through the nozzle passes at a higher speed and at a lower pressure than elsewhere in the nozzle, the method including feeding the chemical gassing solution into the nozzle at or adjacent the restriction in a zone of relatively high speed and low pressure.

7. A method as claimed in any one of the preceding claims, in which mixing the base and gassing solution in the nozzle is effected by passing them together through a mixing device mounted in the nozzle downstream of the positions where base and gassing solution are fed into the nozzle.

8. A cartridge filler nozzle for loading a cap-sensitive water-in-oil emulsion explosive into cartridge shells, the nozzle having a base inlet for non-cap-sensitive emulsion base, an outlet, a gassing solution inlet at a position between the base inlet and the outlet, and a mixing device in the nozzle downstream of the inlets and upstream of the outlet, the mixing device being arranged so that liquids fed simultaneously into the inlets are passed through the mixing device to be mixed together before they issue from the outlet.

9. A nozzle as claimed in Claim 8, in which the mixing device is in the form of an orifice plate or a static mixer, the nozzle having a flow restriction in its interior between the base inlet and the outlet and upstream of the mixing device, and the gassing solution inlet

entering the nozzle at a position in or closely spaced upstream of the flow restriction.

10. A nozzle as claimed in Claim 9, in which the nozzle is of circular cross-section and the flow restriction is centrally located in the nozzle and arranged so that liquid flow through the restriction is axially along the nozzle, the gassing solution inlet to the nozzle being provided by the outlet of a gassing solution delivery tube fast with the nozzle and projecting into the interior of the nozzle, the delivery tube, in the vicinity of its outlet, extending concentrically in the nozzle in a direction away from the flow restriction and towards the base inlet of the nozzle, and the outlet of the tube being directed into the flow restriction.

11. A cartridging apparatus for loading water-in-oil emulsion explosive into cartridge shells, the apparatus including an emulsion base hopper and at least one positive displacement reciprocating dosing pump having an inlet connected to the hopper and an outlet connected to the emulsion base inlet of a nozzle as claimed in Claim 8.

12. An apparatus as claimed in Claim 11, which includes a plurality of said nozzles, each individually connected to an associated said pump, the pumps each being connected to a single said hopper and being operatively connected to drive means, the drive means being arranged to drive the pumps synchronously, so that they undergo working strokes simultaneously.

13. An apparatus as claimed in Claim 12, in which the gassing solution inlets of the nozzles are connected to a common supply vessel, said vessel being in the form of a manifold having an inlet connected to a high pressure part of a circuit for circulating gassing solution under pressure, and an outlet connected to a low pressure part of said circuit, the inlet and outlet of the manifold each being provided with a shut-off valve and the shut-off valves being operatively synchronized with the dosing pumps so that the valve of the manifold inlet opens, and the valve of the manifold outlet closes, at the start of each pump working stroke, and so that the valve of the manifold inlet closes, and

the valve of the manifold outlet opens, at the end of said working stroke.

14. A method of cartridging a cap-sensitive water-in-oil emulsion explosive, substantially as described herein.

15. A cartridge filler nozzle for loading a cap-sensitive water-in-oil emulsion explosive into cartridge shells, substantially as described and as illustrated herein.

16. A cartridging apparatus for loading water-in-oil emulsion explosive into cartridge shells, substantially as described and as illustrated herein.

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